

# **Apparatus for Wide-Ranging, High-Accuracy Fluid $p$ - $\rho$ - $T$ Measurements Based on a Compact Two-Sinker Densimeter**

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An apparatus for high-accuracy fluid  $p$ - $\rho$ - $T$  measurements over wide ranges of temperature, pressure, and density (90 to 520 K; 0 to 40 MPa; 5 to 1700 kg/m<sup>3</sup>) is described. The densimeter is based on the Archimedes (buoyancy) principle and is a double-sinker system incorporating a magnetic suspension coupling; it is described in a companion paper (Lösch, McLinden, and Wagner, abstract submitted to 15th Symposium). The density is obtained directly, without the need for calibration fluids. The complete apparatus, including the thermostat, pressure and temperature measuring systems, auxiliary systems, and computer control, is described. The determination of the sinker volumes and calibrations of the measuring systems are detailed. The traceability of these determinations and calibrations to national standards and fundamental SI quantities is emphasized. The uncertainty ( $k = 2$ ) in density is  $\pm(0.0025 \% + 0.001 \text{ kg/m}^3)$  at 293 K. The uncertainty increases to  $\pm(0.02 \% + 0.001 \text{ kg/m}^3)$  at the upper and lower temperature limits of the apparatus, primarily due to increasing uncertainties in the sinker volumes. The uncertainty in temperature is  $\pm 0.003$  K and that in pressure is  $\pm 0.005$  % to 0.05 %. Results for high-purity nitrogen and a high-density fluoroether are presented to demonstrate the capabilities of this instrument for gases and liquids, respectively.